JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Thermal Analysis of Heat Sink Using Solidworks

Shubham Parihar[1], Ravindra Randa[2]

[1,2] Department of Mechanical Engineering, UIT-Rajiv Gandhi Proudyogiki Vishwavidyalaya Bhopal, Madhya Pradesh, India-462033

[1] shubhamr3736@gmail.com
[2] randa.ravindra@gmail.com

Abstract As technology improves in the field of electronic devices, the cooling of electronic chips is a more significant and challenging issue to be dealt with. With the developments in the field of CFD technologies, it became possible to achieve the optimum cooling performance solution for a designed system in terms of material, size, and shape by computational analysis. The increasing heat load of the device needs to be removed for maintaining the efficient performance of the device. In air-cooled systems, the thermal management systems (i.e. heat sink) are optimized to attain the highest performance in a given space. Adding fins to the heat sink increases its surface area which reduces the heat transfer coefficient of the system. For better performance, a number of fins in a given area is used to optimize the effective performance of the CPU. In this study, a stock heat sink with a central core of different materials and varying heights is analyzed and compared. For analysis flow simulation software, SolidWorks is used to determine the thermal performance of the heat sink. A CPU chip is taken as a volume source of heat power of 65W, ambient temperature is taken as 32 ℃ since the system is already surrounded by other components in the system responsible for increased surrounding temperature. The airspeed produced by the CPU fan is accepted as 1 m/s. Aluminum alloys and Copper is used as heat sink material for this analysis. Further, the results of maximum chip temperature and minimum heat sink temperature for various heat sink geometry are compared and plotted the maximum chip temperature graph for selection of optimal geometry.

1. Introduction

With the development in the electronic industry, electronic devices are more effective and consume more power which in turn produce more heat in a given space due to which the waste heat dissipation method became an important factor. This waste heat, if not rejected, is responsible for increasing the device temperature and causing damage to electronic equipment. While modern CPUs are designed in such a way that they can reduce their temperature by decreasing their performance. There are various ways to extract this waste heat out of the system like Heat Sink arrangement, Liquid Cooler, microchannel heat sink. Where the heat sink arrangement is the most commonly used and cheapest solution for cooling. In Liquid cooling, an assembly of a water block takes away the source heat with the help of a liquid coolant, then the small radiator rejects it to the environment. It is an expensive setup to be used for cooling an electronic device.[1] Microchannel heat sinks are advanced cooling techniques to fulfill the modern-day electronic devices cooling demand, here a nanofluid is used to pass from the microchannels which takes away the source heat out of the system depends on size, shape, and surface roughness.[2] A Heat Sink is the most commonly used setup, to transfer the generated heat in the device to a fluid medium. It is also called a passive heat exchanger used to cool CPUs, GPUs, LEDs, and high-power semiconductor devices. These are directly mounted on the heat source with a very thin layer of thermal adhesive which fills the surface gap in between them. It uses conduction to take away the heat form system and with the help of its extended surfaces rejects it to air by a mode of convection, here an external fan is also used for circulating the air. These are usually made out of aluminum and copper. Due to its low cost, it is widely used for cooling.[3]

Some previous research studies for cooling of electronic devices and focus on parameters during the study. Chiang et al. 2005 [5] studied the heat transfer of desktop computers numerically, and different locations of fans were examined. His investigation focused on the location of the fan on the wall and inlet Reynolds number. Shaeri et al. have conducted a comparative analysis between solid and perforated fin. In which the solid fin performs better than the perforated arrangement in terms of heat transfer rate. Whereas the study performed by Ismail et al. [6] was targeting to evaluate the thermal performance of perforated pin fin arrays for containing hole geometries, including circular, triangular, cubic, and hexagonal shapes. According to the results, the circular perforations gave the best pin effectiveness.

Shriram and Ravindra [7] in their research analyzed microchannel heat sinks of SMPS fins. With the help of Ansys Fluent 14, they have compared square and circular pin fins with parallel plate fins. Analysis was conducted on Aluminium, copper and nickel material, where both Square and Circular pin fin with Al and Cu show appreciable increase in heat transfer. While Nickel very near the results . Iyengar and Bar-Cohen [8] compared pin-fin and plate-fin heat sinks that were optimized by a least-material method. In which the optimum fin thickness is determined for a given fin height. Then, optimum fin spacing between the adjacent fins by maximizing the amount of heat dissipated from an array of various values of the spacing. From the results, the optimized pin-fin heat sinks dissipate more heat than the optimized plate-fin heat sinks. However, there are some inherent limitations in the least-material method. Goshayeshi and Ampofo [9] conduct numerical studies on vertical fins, attached to the surface. Natural convective mode of heat transfer is found from the heated plane, which is kept into the air with horizontal and vertical surfaces. Results show that a vertical plate with dimensionless performances is best for natural cooling.

Here our study is focused on to find the maximum and minimum temperature reached by the chip, using various combinations of Copper central core of different heights with an Aluminum heat sink, and compare it with the Solid Aluminum and a Solid Copper Heat Sink performance in similar boundary conditions. Two different heat sinks use for this analysis:

(I). Straight Fins Heat Sink

(II). 10 degree incline Fins Heat Sink

2. Modeling and Simulation

This involves modeling of CPU, Baseplate, Heatsink, Central Copper Core of various heights, and Fan Space using DS Solidworks 2017 and then simulation runs on SolidWorks flow simulation. The analysis is done on Aluminum Alloy Heatsink, Aluminum with a Central Copper Core with a height of 5mm, 10mm, 15mm, 25mm, and then a complete copper heatsink.

2.1 Modeling

The modeling consists of a base plate on which the CPU chip with its heat spreader on which heat sink arrangement is installed and a fan section to produce airspeed. Here two types of the heatsink are used one with a straight fin and one with an inclined fin to the axis of 10 degrees and both with a copper core of height 5mm, 10mm, 15mm, 25mm

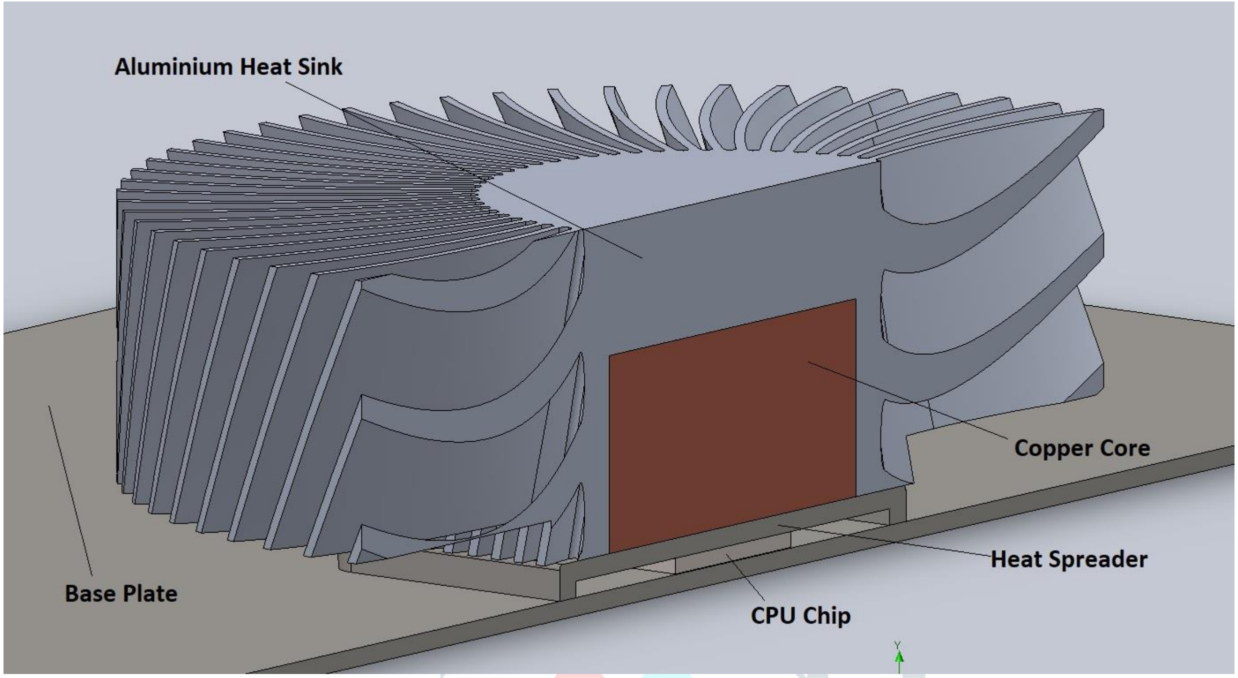

Fig. 1 10º inclined Aluminum HeatSink with Copper Core on CPU

Component	Length x Width	Diameter	Height / Thickness
Base Plate	200 x 200	Nil	1.4
CPU Chip	22 x 14	Nil	1.2
Heat Spreader	42 x 42	Nil	2.75
Heat Sink	Nil	90	25
Copper Core	Nil	30	Varying

Table 1: The dimensions of the component given above (in mm)

2.2 Simulation

In this, the assembled models are put into the SolidWorks fluid flow simulation set for external Thermal Analysis. Where first we defined the computational domain and assigned materials to every part, considering the fan section in the fluid subdomain with generating airspeed of 1 m/s. Power input is applied on the CPU Chip as a Volumetric Heat Generation Rate of 65W.

	Value	Description
Ambient Temperature	32 ℃	In Computer Case other devices also generate heat.
Power Input	65 W	Volumetric Heat Generation Rate on CPU Chip

Table 2: Boundary Conditions of the assembles.

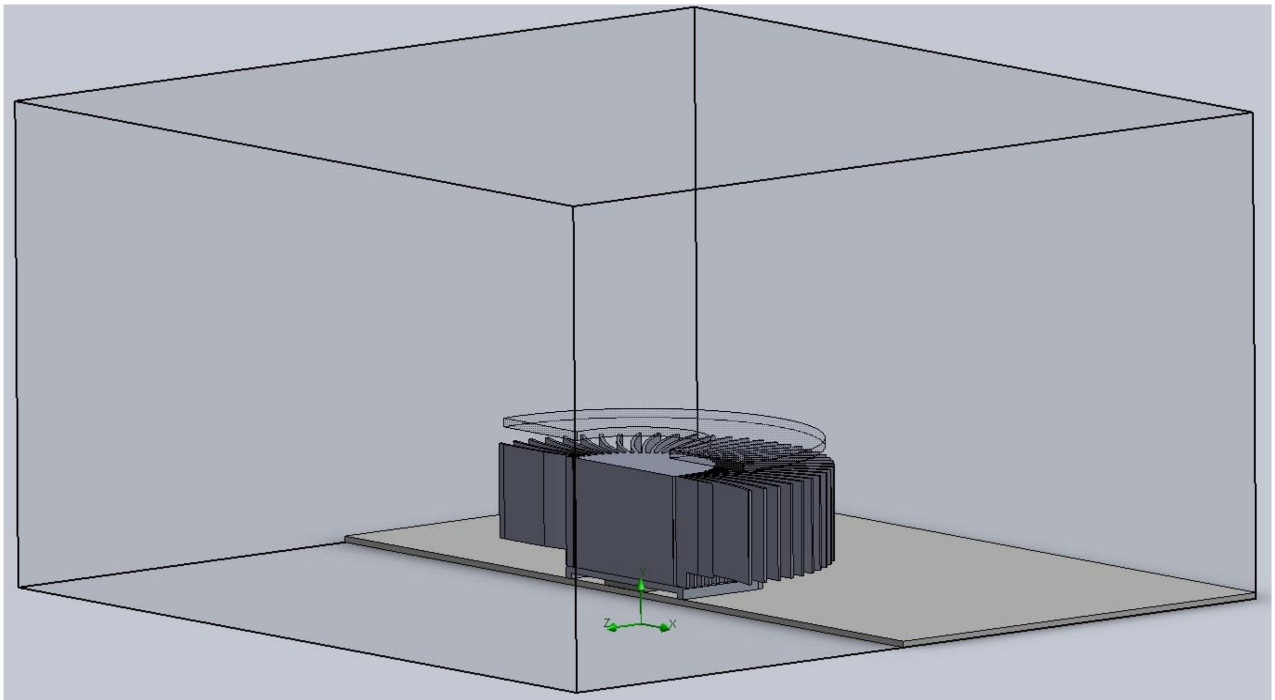

Fig. 2 Aluminum HeatSink inside Computational Domain

In the fluid flow analysis to find out the maximum CPU Chip temperature without any heat sink, one arrangement of the chip with heat spreader on the base plate is analyze with the ambient temperature of 32 ℃ and a power output of 65 W, considering the base plate isolated and without airflow, results are as following, the maximum chip temperature reached to 213.09 ℃ and minimum temperature on heat spreader of about 164.26 as displayed in Fig. 3

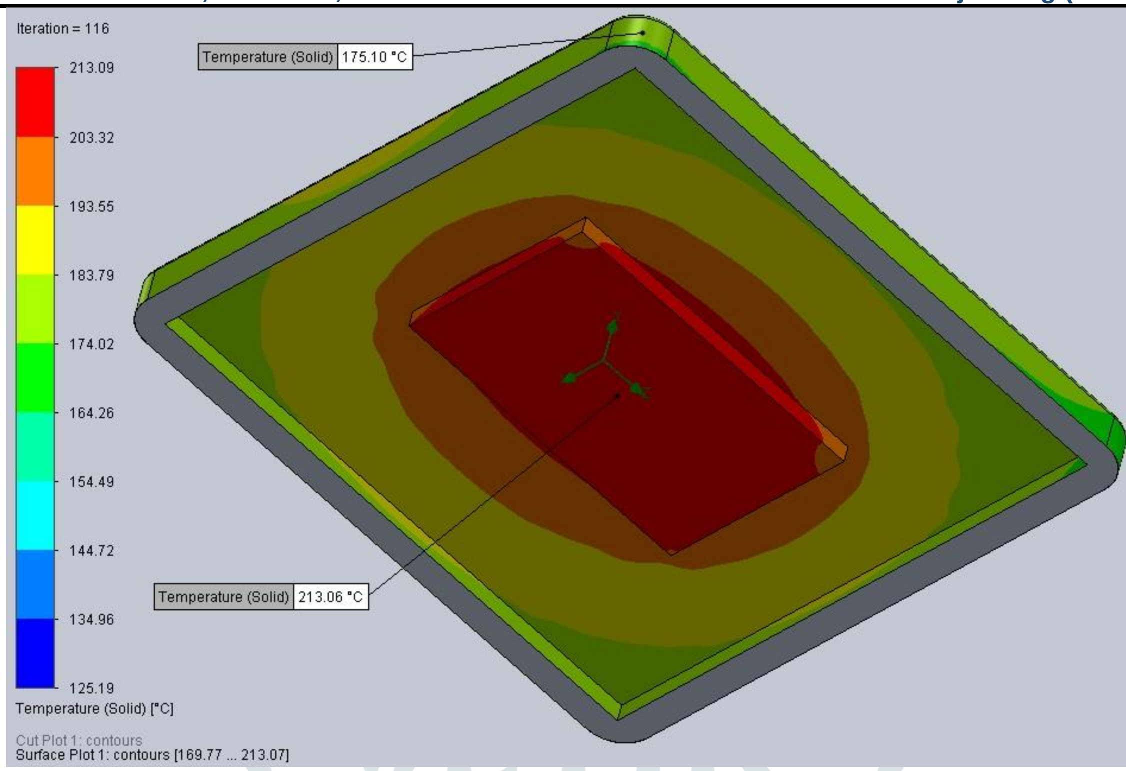

Fig. 3 Temperature distribution (℃) of CPU Chip with Heat Spreader

Property	**Aluminium 6061**	**Aluminium 6063**	**Copper**	**Silicon**
Density, Kg/m	2700	2700	8900	2330
Thermal conductivity, W/m.K	170	218	390	124
Specific heat, J/Kg.K	1300	900	390	–
Material Used For	For HeatSink	For Heat Spreader	For Copper Core	For CPU Chip

Table 3: Properties of material and where used.

After the Solid Aluminum heat sink calculation and solution is displayed in the form of temperature distribution across the section of the heat sink. The Similar calculation is performed for Al + 5mm Copper Core, Al + 10mm Copper Core, Al + 15mm Copper Core, Al + 20mm Copper Core, Al + 25mm Copper Core, and then for heatsink with fins at a 10-degree incline with the axis of the heat sink and their combination with a copper core.

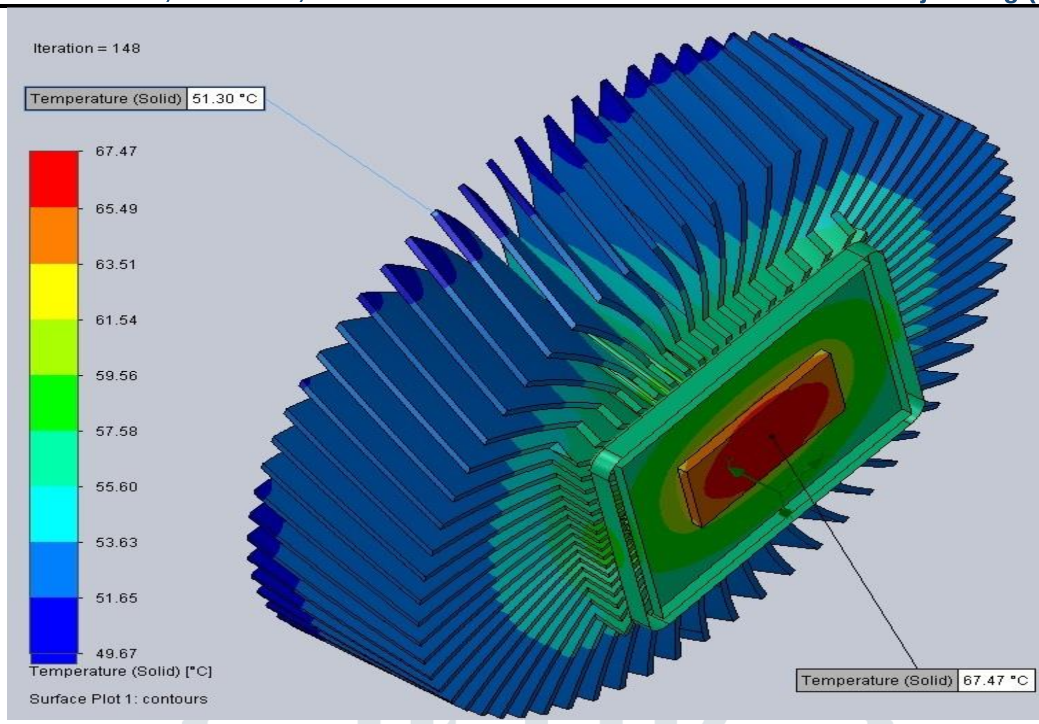

Fig. 4 Temperature distribution (°C) of 10 degree incline fin Solid Heatsink with Aluminum

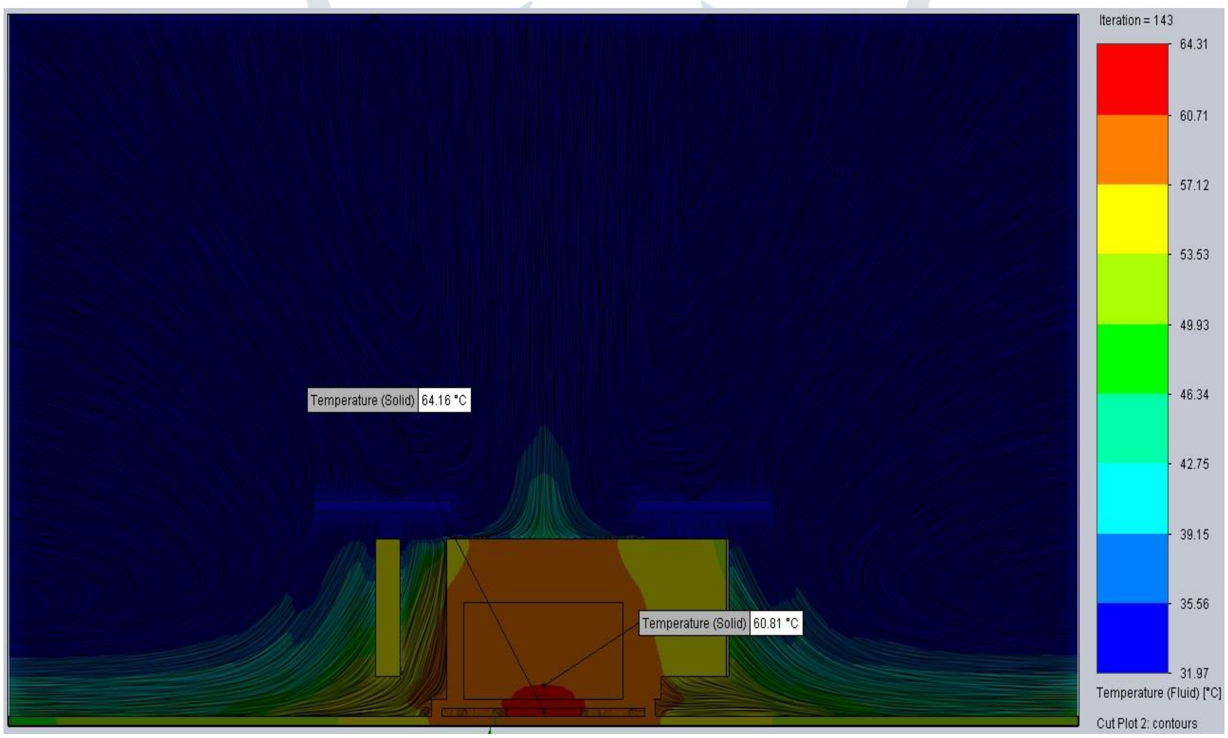

Fig. 5 Temperature distribution (°C) of straight fin Al+15mm Copper Core Heatsink

3. Results and Discussion

After all the simulations were completed, taking all the other parameters like power input, airspeed, and initial temperature the same and replacing the central region with a copper core. In step by step increasing the core height from 5mm to 25mm which is the maximum height of the heatsink, the simulation results of maximum and minimum temperature are as follows on Table 4.

It is clear that a heatsink improves the heat transfer from the CPU Chip. The maximum temperature Regan is the CPU Chip part which is a heat source while the minimum temperature region is the fin tip in contact with the fluid medium.

	Straight Fin Heat Sink		**10 degree incline Fin Heat Sink**	
Heat Sink Arrangement	**CPU Chip Temp.** (max.) [℃]	**HeatSink Temp.** (min.) [℃]	**CPU Chip Temp.** (max.) [℃]	**HeatSink Temp.** (min.) [℃]
Solid Al Heat Sink	67.9015	52.1419	67.4697	51.2391
Al+Cu 5mm Core	64.752	51.9163	64.6304	51.3452
Al+Cu 10mm Core	64.6406	52.3471	63.8709	51.3335
Al+Cu 15mm Core	64.3066	52.3439	63.5242	51.3269
Al+Cu 20mm Core	64.3191	52.4713	63.5194	51.4447
Al+Cu 25mm Core	63.9983	52.2555	63.455	51.4466
Solid Cu HeatSink	61.8402	53.5786	61.0639	52.6125

Table 4: Maximum and Minimum temperature of CPU Chip and Heatsink with various Arrangement

The graph of the result of maximum chip temperature is displayed on the graph between temperature and the heatsink arrangement in Fig. 6 for both straight and 10-degree incline fin heatsink.

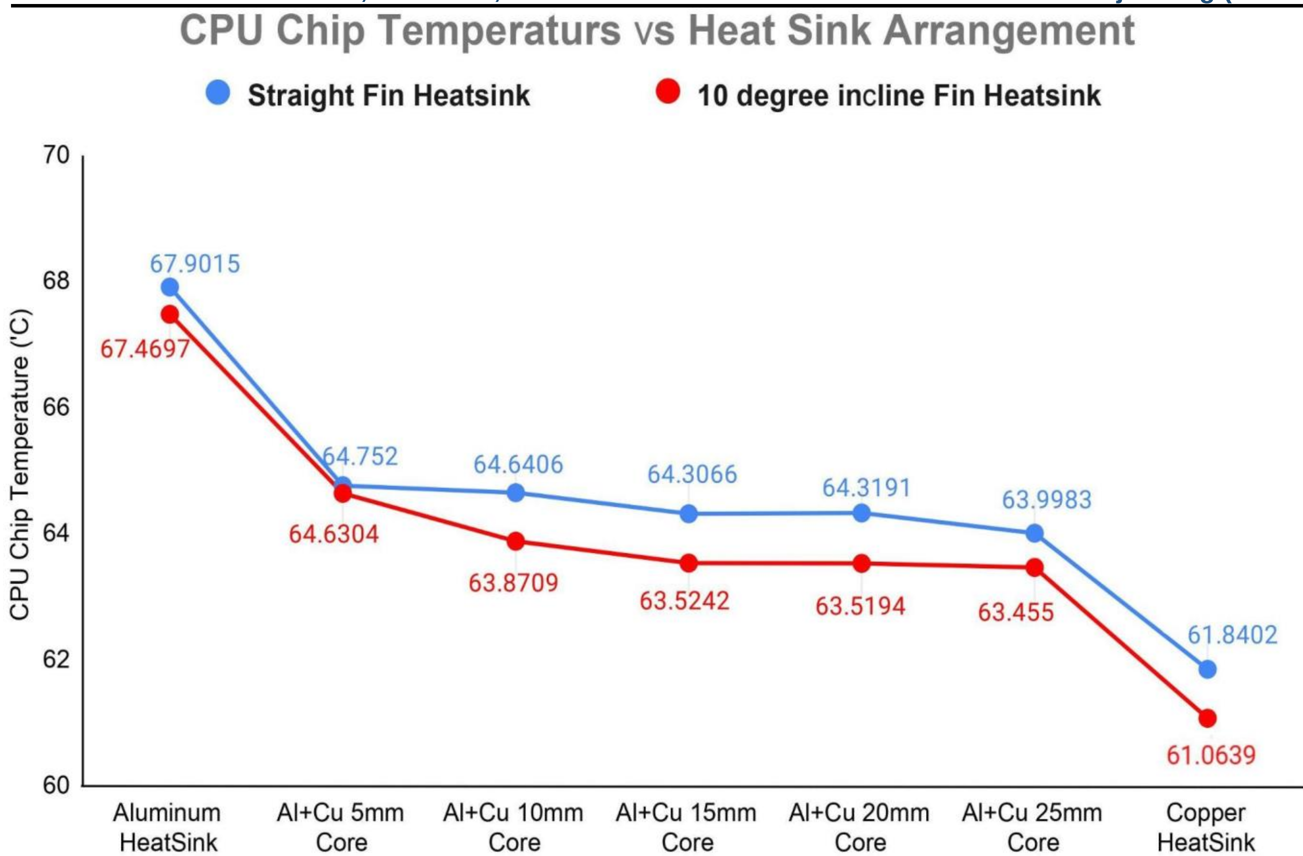

Fig. 6 Maximum Temperature (℃) graph between CPU Chip and Heatsinks arrangement.

4. Concluding Remarks

The Results demonstrated the effectiveness of using a heat sink with a core in reducing the CPU temperature. In this paper, the heatsink with a copper core of different heights was investigated using Solidworks flow simulation and the results were acceptable. The heatsink with a 5 mm copper core shows more than 3 °C temperature drop while further increasing the size makes the difference too.

While Using the 10-degree incline fin heat sink, the performance seems better in comparison to a straight fin heat sink of a similar combination with a copper core. This study can help in selecting composite heat sinks as per performance and the amount of material used. Future studies are also possible by varying other parameters and the core shape and size used in the analysis.

References

[1] https://en.wikipedia.org/wiki/Liquid_cooling.

[2] https://link.springer.com/article/10.1007/s11630-020-1334-y.

[3] https://en.wikipedia.org/wiki/Heat_sink.

[4] Ravindra Randa, Sumit Singh, "CFD Analysis of Conical Coil Tube Heat Exchanger with Varying Cone Angle", IJRASET, Volume 5 Issue V, May 2017, ISSN: 2321-9653

[5] J.S Chiang, S.H.Chuang, Y.K.Wu, H.J Lee, "Numerical Simulation of Heat transfer in Desktop Computer with Heat Generating Components", International Communication in Heat and Mass Transfer 32 (2005) 184-191.

[6] M.F. Ismail, M.N. Hasan, M. Ali, Numerical simulation of turbulent heat transfer from perforated plate-fin heat sinks, Heat Mass Transfer 50 (4) (2014) 509–519.

[7] Shriram, Ravindra Randa, “Enhancement of Thermal Performance of Microchannel Heat Sink Used in Computer SMPS Fins by using CFD”, International Journal for Scientific Research & Development| Vol. 5, Issue 03, 2017 | ISSN (online): 2321-0613

[8] M. Iyengar, A. Bar-Cohen, Least-material optimization of vertical pin-fin, platefin, and triangular-fin heat sinks in natural convective heat transfer, in: The Sixth Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems, ITHERM 98, IEEE, 1998, pp. 295–302.

[9] H. R Goshayeshi, F. Ampofo, “Heat Transfer by Natural Convection from a Vertical and Horizontal Surfaces Using Vertical Fins”Energy and Power Engineering, 2009, 85-89.

[10] Subodh Kathane, Mr. Ravindra Randa, “CFD Analysis of Engine Cylinder FIN” IJRASET, Volume 5 Issue VI, June 2017, ISSN: 2321-9653

[11] Seri Lee, International journal of “Optimum Design and Selection of Heat Sinks,” Eleventh IEEE SEMI-THERM Symposium, pp. 48-54, 1995

[12] Mr. Ravindra Randa, Shriram, “Review of some useful Techniques and Parameters for Thermal Performance Enhancement of Microchannel Heat Sink”, Volume-7,Issue-5, May-17, ISSN (O): 2349-3585